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Hoboken, N.J. Water Supply
J.C. ; N.J.

REPORT

OF THE

WATER COMMISSIONERS

OF

HOBOKEN AND JERSEY CITY,

WITH

AN APPENDIX.

Ward, John D. and others.
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1852.

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REPORT.

To the Honorable the Senate and General Assembly of the State of New Jersey:

By an Act of the Legislature, passed 18th March, 1851, the undersigned were appointed a Board of Commissioners, to "examine and consider all matters relative to supplying Hoboken, Van Vorst and Jersey City, with a sufficient quantity of pure and wholesome water for the use of their inhabitants, and the amount of money necessary to effect that object."—Having made the examinations directed by the Legislature, and considered all such matters relating to the object of their appointment, as they supposed would assist them in arriving at correct conclusions with regard to the best means of attaining it, they, as directed, respectfully submit the result of their labors in the following REPORT:

Before entering upon the search for a supply of water, the Commissioners supposed it proper to ascertain the quantity which will be required, when the whole space comprised within the present limits of Hoboken and Jersey City and that part of Bergen Hill, lying south of a point sufficiently elevated for a distributing reservoir, shall be covered by a dense population. Within this district, it is supposed that at least two hundred and fifty thousand persons may at some future day reside; and that all or nearly all this number will require to be supplied with water from the works now contemplated. The Commissioners were led to this latter conclusion, by considering, first,

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that a large proportion of the space mentioned, was originally a deep marsh, over which the tide occasionally ebbed and flowed, from which, of course, no water fit for domestic use can, by any means, ever be obtained; and next, by the fact, that a large proportion of those wells which have been sunk upon the higher ground, afford during the summer and autumn, only a small quantity of very impure water; and scanty as the supply is, which they now afford, it is annually becoming less, and its quality more objectionable.

It having been found by experience, that a full supply of water for all purposes, requires an average of at least thirty gallons per day for each person, the Commissioners concluded, that, in order to fully satisfy the requirements of the law under which they act, they were bound to find, if possible, a source from which that quantity may be regularly drawn for each individual of the quarter of a million which they have supposed may require it. It was also concluded, in order to render it completely effective for the extinguishment of fires, and to enable consumers to obtain it conveniently in all parts of the highest buildings into which it may be introduced, that the surface of the water in the distributing reservoir, ought not to be less than from one hundred and twenty to one hundred and thirty feet above high water in Hudson river. In other words, it was decided, that the source from which the water is to be obtained, should be one that will regularly, at all times and in all seasons, afford at least seven millions five hundred thousand imperial gallons per day, and that the design for the works should be such, that, when entirely completed, they will regularly deliver that quantity to the consumers, from an elevation of at *least* one hundred and twenty feet above ordinary high water. A small proportion only of this will be wanted at present, or for several years to come, as about five hundred thousand gallons per day would be a good supply for the present population. But as the present population will probably be doubled within the next ten years, especially if a good supply of water is obtained, it may be sound policy to execute at first so much of any plan which may be adopted, as will supply two

or three times the present number. But whatever part may be considered necessary at first, should be constructed in such way as to constitute a symmetrical part of the whole, when completed.

Entering upon their labors with these views, the Commissioners first visited Hackensack river, and examined the small streams falling into it, from the western side of Bergen Hill, between the railroad bridge and English Neighborhood, a distance of about twelve miles. They next examined Passaic river at Paterson, at Dundee, Acquackanonck and Belleville; and a committee of the Board visited and examined Rockland lake. In the course of these examinations, a considerable amount of information was collected, of such character as led to the conclusion, that engineers and surveyors might then be advantageously employed, for the purpose of determining the proper source from which the supply of water should be taken, and the most efficient and economical plan for bringing it in, and distributing it to the consumers. They therefore, on the 22d July, engaged William S. Whitwell, Esq., late chief engineer of the eastern division of the Boston water works, for the purpose of making such examinations, surveys, plans and estimates, as were necessary to enable the Commissioners to decide upon the relative value of the various plans and suggestions which had been brought to their notice, and were supposed to deserve further attention.

Mr. Whitwell arrived with a surveying party on the 26th August, and commenced operations near the village of Belleville. He was furnished with written instructions respecting the work to be performed, in which his attention was directed to such of the plans as the Commissioners supposed would require a professional examination; and he was requested to report upon such of them as were, in his opinion, of such character as to repay the labor of an inquiry into their merits.

The Commissioners also requested Messrs. Clerk & Bacot, city surveyors, to make such surveys and examinations as would enable them to compile a connected map of Hoboken and Jersey City, and to include in it that part of Bergen Hill,

lying eastward of the proper situation for a distributing reservoir, and to designate upon the map, when drawn, those places which are now built upon. This map was necessary for finding the lengths of, and determining the proper sizes for the distributing pipes, the number and sizes of stop-cocks, fire hydrants, &c., which will be required in the streets for the purpose of distributing the water to the consumers and rendering it effective for the extinguishment of fires.

These measures were adopted to enable the Commissioners to obtain all the facts and circumstances relating to a sufficient supply of water, and have them recorded in such form, that they can be preserved and rendered available at any future time; if the estimates should show that the cost of the work would be greater than could be safely ventured upon at present.

Among the various plans for obtaining "a sufficient quantity of pure and wholesome water," the first which came under consideration, was contained in a report made by Messrs. Clerk & Bacot, to a committee of the Common Council, in relation to a supply of water for the inhabitants of Jersey City, dated 1st November, 1847. This report, after detailing the examinations of several springs and small streams, recommended taking the water which finds its way into a small reservoir, which has been excavated at the side of the New Jersey railroad, a short distance westward of the summit of Bergen Hill. The largest quantity which could be obtained from this place was estimated at two-hundred and fifty thousand gallons per day;—and it was proposed "to elevate this by means of a steam engine to a distributing reservoir to be made on the top of the hill—the bottom of which, to be at least seventy-five feet above tide." But, as the present population of Hoboken and Jersey City amounts to about seventeen thousand, this quantity would furnish each individual with a little less than fifteen gallons per day, or less than half the quantity, which experience has shown to be necessary.

The next plan which came under consideration, was one for damming the Hackensack river, at some place not far distant from the railroad bridge, and extending embankments across

the adjoining meadows to the high ground on both sides, for the purpose of preventing the tide from flowing beyond the line of the dam. As the salt water would, by this means, be prevented from mingling with the fresh water above the dam, it was supposed that in a comparatively short time the bed of the river and the adjoining grounds would be so completely drained of salt and all other impurities that the water flowing in the river above the dam would be pure and wholesome, and could be pumped from an open lateral cut directly into a distributing reservoir, constructed in some convenient situation on Bergen Hill. But as the quality of the water in that part of the river at present beyond the reach of the tide, is reputed to be indifferent, being strongly tinctured with decaying vegetable matter, and as the plan was sure to be expensive and its success by no means certain, the Commissioners did not feel bound to bestow a great deal of time or labor in its examination.

Another plan offered for consideration, was to obtain the water of Rockland lake, situated in Rockland county, in the State of New York, and distant from Jersey City about thirty-three miles. The surface of the lake, at a medium height of water, is one hundred and forty-five feet above ordinary high water in the Hudson river, and its extent is about five hundred acres. The quality of the water which flows from it is excellent, and it might, no doubt, in an aqueduct of proper grade and dimensions, be brought into a distributing reservoir, at a sufficient elevation, to serve the purposes for which it would be required. But such an aqueduct, including land damages and other expenses, would probably cost at least fifty thousand dollars per mile. The lake is situated out of the jurisdiction of the State of New Jersey; and after careful examination, it was pretty satisfactorily ascertained, that the greatest amount of water it could be relied upon to furnish would fall considerably short of two millions of gallons per day. It appears, therefore, that if the water could be obtained gratuitously, the cost of bringing it from this source into a distributing reservoir, would be something more than one million five hundred thousand dollars; to which would have to be added the cost of

distribution ; and the quantity which would be obtained by this expenditure, would be less than one-fourth of what the Commissioners suppose will at some future time be required.

Another plan suggested, was to make use of so much of the western slope of Bergen Hill for a gathering ground, as would serve to furnish the necessary quantity of water. The water to be that portion of the annual fall of rain which would sink into the soil, and be gathered into an extensive net work of drains, excavated to the proper depth, and partially filled with loose stones, or furnished with earthen-ware drain pipes, having loose joints to admit the water—the trenches then to be filled with loose earth to the level of the general surface. The water thus collected to be conducted into an aqueduct, at the base of the hill, to be conveyed by it to a large storing reservoir, and pumped from that to a distributing reservoir on the summit.

Of the success of the plan for collecting water, little has been learned by experience—the Commissioners have not been able to find that it was ever resorted to, where any considerable quantity, or a regular supply was desired, except for a part of the water required for the use of the city of Edinburgh.

At the distance of nine or ten miles from that city, a pretty extensive valley, elevated five hundred and sixty-four feet above the level of the sea, and having a bed of coarse gravel resting upon a compact rock, has been made to afford one hundred and eighty cubic feet of water per minute, or one million six hundred and twenty thousand imperial gallons per day, at an expense, for the whole work, of one hundred and forty-five thousand pounds sterling, or something more than seven hundred thousand dollars.

In an experiment continued for three years at Manchester, by the late Mr. Dalton and Mr. Hoyle, it was found that at the depth of three feet below the surface, almost exactly one-fourth of the water fell was collected in an apparatus fixed for that purpose, the mean annual fall having been 33.55 inches, and the mean annual amount collected 8.41 inches. But during nine of the thirty-six months through which the observations were

carried on, no water at all was collected; and during six other months, the average quantity per month was only .1066 inch, showing that eighty-two eighty-fourths of the whole amount was collected during seven months of the year, and only two eighty-fourths in the remaning five months. In fact, more than three-fourths of the whole was collected during the five months of January, February, May, November and December in each year.

This last is an important fact, as it goes to show, that if this plan is used, large storing reservoirs, capable of holding at least half a year's supply must be provided, in which the water obtained during the wet season, may be stored up for use in that part of the year when the underground drains would be entirely dry.

In this vicinity, the annual fall of rain generally ranges between forty and forty-eight inches, and upon a level, or nearly level surface, and a gravelly or other porous soil, probably about the same proportion of this could be collected, that was obtained of the annual fall in Manchester, or an average of about eleven inches per annum.

But the western slope of Bergen Hill does not appear to present a favorable situation for the successful operation of this plan. The inclination of the surface is such, that a large proportion of the water falling upon it, must run off without sinking into the soil; and the strip of land which could be made to contribute to the supply, is so narrow, that in order to drain a sufficient extent of surface to furnish the required quantity, the receiving aqueduct at the base of the hill, must be of great length, and as it would require to be built to retain the water, it would be very expensive.

If, in situations favorable to the absorption of water falling upon the surface, not more than ten or twelve inches of the forty to forty-eight inches which annually fall in this part of the country, could be collected by a system of gathering drains, it would be unsafe to rely upon more than nine or ten inches from ground having so great an inclination as the side of Ber-

gen Hill. But even if ten inches could be obtained from the whole surface, the area required to furnish the quantity which the Commissioners have supposed necessary would be upwards of twelve thousand acres, or about nineteen square miles; and a reservoir to store up the six months supply which must be provided, in order to render the plan successful, must be of such capacity, as would be afforded by a depth of nineteen feet, and an area of three hundred and twenty acres. With regard to the quality of the water which might be obtained by adopting this plan, an opinion may be formed from the result of an analysis, by Dr. Chilton, of a specimen of that which is now collected in the railroad company's small reservoir at the side of the road—the same recommended as the source of supply in Messrs. Clerk & Bacot's report, before referred to. This was found to contain 16.06 grains of solid matter in a gallon;* and there is no good reason for supposing that other parts of the hill will afford water differing materially in its character from this. But as no situation presents itself for the construction of such a reservoir as this plan would require, as the receiving aqueduct would, from the situation of the gathering ground, be nearly or quite twenty miles in length, if the works were completed, as the plan would necessarily be a very expensive one, and as there are strong reasons for doubting its success, if executed, the Commissioners could not recommend its adoption, even if its execution appeared practicable.

The next plan which came under consideration, was one for taking water from the Passaic river, above the falls at Paterson. A proposition was made by Roswell L. Colt, Esq., president of the "Society for Promoting Useful Manufactures," to furnish from the upper canal, which conducts the water to the mills, as much as would pass through an aperture of one and one-half square foot area, with a head of thirty inches above its centre. The plan proposed for bringing it to Jersey City, was to lay down a line of iron pipes, from the side of the canal to the Paterson railroad station, and along the line of the road across the Passaic and Hackensack rivers, to some convenient

* See Appendix D.

spot for constructing a distributing reservoir. Such an aperture, with a head of thirty inches, would discharge nearly six and a-half millions imperial gallons per day; and the cheapest mode of bringing that quantity to Jersey City, would be by a single line of thirty-six inch pipes; which, to accomplish this purpose, would require to have an inclination of about twenty-eight inches per mile. The height of the water at Paterson, is said by Mr. Colt, to be one hundred and six feet above tide, and the distance from the place at which the water was proposed to be delivered, to the point at which the Paterson railroad diverges from the New Jersey road, is nearly fourteen and one-third miles. If a pipe thus laid, should deliver the water into a reservoir, at or near the junction of the railroads, its elevation, after deducting the twenty-eight inches per mile, required to produce the necessary rapidity of flow, would be about 72.58 feet above tide, or 47.42 feet below the minimum height, which the Commissioners have supposed necessary. The water would therefore have to be pumped by a steam engine from the reservoir, into which it would be first received, to a second or distributing reservoir having the necessary elevation.

The price for which this quantity of water was proposed to be delivered, was four thousand dollars per annum, a rent which represents a capital of $66,667; the cost of thirty-six inch pipes when laid, would not vary much from $60,000 per mile, exclusive of the right of way. To the cost of the water and the pipes for bringing it, would have to be added the cost of receiving and distributing reservoirs, steam engine, pumps, distributing pipes, &c., as shown in the comparative views of the cost of several of the proposed plans which are examined in the engineer's report.

This plan, with some modifications which would be required in its execution, would furnish a supply of excellent water for many years to come, but would be found insufficient, should the number to be supplied ever reach much beyond two hundred thousand. The cost of pumping from one reservoir to another, nearly fifty feet above it, would be a pretty large proportion of the cost of pumping from the level of the tide, and

ought not to be encountered, unless other parts of the plan present advantages sufficient to counterbalance the expense of that operation.

The character of the plan, too, seems to be such, as not to admit of its being executed in parts, or making it a small work at first, and extending it from time to time, as the wants of an increasing population might render necessary,—but must be constructed at once of full size, and capable, from the first, of bringing all the water, which from this source, will be likely ever to be obtained. The interest upon the cost of the complete work would therefore have to be encountered at once by a small population, requiring but a small proportion of the water which would be delivered, and several years would necessarily elapse, before the number would be sufficiently increased to relieve the oppressive burthen, which so large an expenditure at the present time would impose.

Another plan proposed by Mr. Colt, was to furnish a given quantity of water from the Passaic river, at Dundee, (eleven and a-half miles from Jersey City), where, as he informed the Commissioners, the top of an intended dam will be twenty feet above ordinary tides. The quantity which he proposed to deliver there, was that which would pass through an aperture, having an area of five square feet, and a head of thirty inches above its centre—four feet of this, to be used for working a water wheel and pumping machinery, to elevate the remaining one foot into a reservoir elevated seventy-five feet above tide, from which he supposed it could be taken in pipes to Jersey City. This amount of water Mr. Colt proposed to convey, by lease, renewable every twenty-one years, forever, on payment of an annual rent of $3,000, and one year's rent as a fine for each renewal. The quantity which would flow through an aperture of one foot square, under a head of thirty inches, would be nearly 4,200,000 imperial gallons in twenty four hours, or two-thirds the quantity which was proposed to be delivered at Paterson.

It is possible, that if, at some future day, a larger quantity should be required, it might then be obtained; but it is also

possible, that at the time when wanted, the whole of the water might be appropriated in such way, that its acquisition would be attended with a heavy expenditure, and might be found impracticable.

To render this plan successful, however, the receiving reservoir, into which the water must be pumped, should not be less than one hundred and forty feet above tide. To pump one foot of water to this height, or one hundred and twenty feet above the ridge of the dam, would require, with the best machinery in use, not less than eight feet upon a water wheel, worked under a fall of twenty feet; and this additional quantity of four feet, if charged at the same rate as proposed for the five feet offered, would increase the annual rent to five thousand four hundred dollars.

One thing in relation to the water, which Mr. Colt, at Dundee and at Paterson, appears to the Commissioners objectionable; the title to, or ownership of it, will not be as perfect as is desirable.

It must not only be taken under a lease, but held in common with other lessees, or proprietors, possessing equal rights and privileges; and an inadvertent omission to pay the rent at the stipulated time, or a real, or a fancied violation of some covenant of the lease, or a disagreement among the lessees, with regard to the equitable division of the water in times of scarcity; these, and perhaps other causes, might lead to vexatious and expensive law suits, which might result in a stoppage of the supply, after being at the whole expense of constructing the works. The risk of difficulties of this kind, and the propensity frequently, if not generally, exhibited by courts and juries to decide suits at law, in favor of individuals, where corporations, or public bodies are the opposing parties, have led the Commissioners to regard with some apprehension, every arrangement for a supply of water, which appeared to present any opening for future litigation, which could effect the title, or in any way interfere with the enjoyment of the right once obtained.

It was also proposed, to obtain a supply of water from that level of the Morris canal, which extends from above the Little

Falls of the Pasaic river to Bloomfield. This level is one hundred and seventy-four feet above tide—an elevation sufficient to allow the water to be taken in pipes from the settling reservoirs at the side of the canal, and conducted by the most direct route to the distributing reservoir on Bergen Hill; into which it might be delivered at one hundred and forty or one hundred and fifty feet above ordinary high water. This would be a very desirable elevation, and as the water would be conveyed into the reservoir without the use of machinery, and of course without the constant expense which its use entails, the plan has received a careful examination.

This level of the canal, is, to a considerable extent, supplied with water which is collected in Greenwood lake or Long Pond, which lies partly in Passaic county, New Jersey, and partly in the State of New York. The lake discharges its waters into Ringwood river, which unites with the Ramapo river, and this soon after unites with Pompton river, from which a feeder is taken to the canal, at a short distance above the Little Falls. The area of the lake, at its present height, is about two thousand acres, and it receives the water which drains from twenty-seven thousand acres of land around its borders. By raising the dam at the outlet, a sufficient quantity of water might be stored in the lake, during the wet season, to keep up a regular supply to the mills upon the Pompton and Passaic rivers, below the feeder, during the dry season, and to enable the canal to furnish the water required for Hoboken and Jersey City.

The quality of the water flowing in Pompton river is excellent; and although it may contract some impurities, while flowing twenty miles in the canal and feeder, these could be got rid of, by taking it into two settling reservoirs, of sufficient size to contain a supply for several days—drawing from these alternately, and filling them again as soon as emptied, so that the water might always remain several days at rest, before being drawn off. This would give time for the impurities, (which are merely held in suspension,) to be deposited, when the water would be sufficiently pure for domestic use.

These settling reservoirs, to accomplish their purpose satisfactorily, would require to be of considerable extent, as the water in them could not be drawn to a very low point, without lessening the flow through the pipes conveying it to the distributing reservoir, to such an extent, as to interfere with the regularity of the supply, or rendering it necessary to reduce the elevation of that reservoir below what would be desirable. If the works were so arranged that the water could be drawn down twelve feet, and the quantity required should reach seven million five hundred thousand gallons per day, each reservoir would require to have an area of about two and a quarter acres for every day the water would be allowed to remain in it for the purpose of purification.

Greenwood lake and the streams mentioned above, are tributaries of the Passaic river, and some doubt exists with regard to the right of the "*Morris Canal and Banking Co.*" to sell or dispose of the water, in any way that shall withdraw it from the canal. It is contended, that the Legislature authorized the Company to use the water *only* for the purposes of navigation, and intended that the same amount that is withdrawn from the Passaic or its tributaries, shall be returned to that stream again. If this is the true view of the case, some action of the Legislature would probably be necessary, before any water could legally be withdrawn from the canal.

But there is no doubt, that if the works were properly constructed and well managed, the owners of the mills and water power, on those parts of the river which would be affected by them, would not only not be injured, but might be greatly benefitted, by having a pretty large proportion of the water retained in the lake during the wet season, and delivered to them in the dry. Although the whole quantity which would pass the mills would be less than at present, they would have a better supply during the dry season of the year, and would be less incommoded by the floods of the winter and spring.

This mode of equalizing the supply to mills affected, by taking water for the supply of towns and cities, has been practiced with perfect success at Edinburgh, Greenock and Boston.

And it has lately been proposed to supply the same principle, in very extensive works, for equalizing the flow in the Ohio and Mississippi rivers, for the double purpose of improving the navigation of the former in the dry season, and preventing the extensive injury frequently caused by the latter overflowing its banks in the wet season—and if the owners of the water power could be induced to agree to an arrangement for such a disposition of the water, there is no doubt that the plan would operate successfully in this case. But unless some definite and satisfactory agreement could be made with the canal company and the owners of the water power, by which the regulation of the supply required for Hoboken and Jersey City, should be placed *completely* within their control, the Commissioners would hesitate to recommend taking water from the canal; because, without this control, the amount and regularity of the supply would be to a considerable extent dependent upon the action of those who would not suffer by its interruption or diminution, and whose interests would lead them to appropriate to their own use, all but the smallest quantity which they could induce the water consumers to accept. The Commissioners to examine the sources of supply for the city of Boston, in 1845, remark in their report, that "any partner or joint ownership will entail controversies and embarrassments, that will more or less interfere with the enjoyment of the city portion of the right, and which should not be permitted in a matter of so much importance as the proposed work."

The cost of obtaining a supply of water from this source, if it should, on further examination, be deemed the best, will be seen by referring to the engineer's report, to be as follows:

Price demanded by the Morris Canal and Banking Co. for the water, .	$250,000
Cost of works, as per estimates, .	719,396
Total,	$969,396

Having examined all other sources from which it appeared at all likely a supply could be obtained at a moderate cost, we come now to that part of the Passaic river, which flows between

Acquackanonck and Belleville. Here the quantity of water is abundant, and may be withdrawn from the river, without materially, if at all, interfering with private rights—and its quality, as appears by the analyses of Dr. Chilton and Professor Horsford,* as well as from the united testimony of all the residents upon the banks of that part of the river, is unexceptionable. The water may be taken from the river at a short distance above Belleville, in a lateral canal, pumped by a steam engine into a receiving reservoir, on the summit of Barbadoes Neck, or Copper Mine Ridge, at an elevation of one hundred and fifty feet, and will flow from that into the distributing reservoir on Bergen Hill. The distance from the distributing reservoir to the point on the river from which the water may be taken, is about six and one-fifth miles—a line considerably shorter than is offered by any other plan examined, which would furnish an adequate supply. The ground on this route is well suited for the construction of the canal, engine house, receiving reservoir, and other structures required. This plan, which was suggested by the engineer, and recommended by him as superior to any other, is deemed by the Commissioners the one best suited to the present and future wants of Hoboken and Jersey City—or it is in "*their opinion, the best plan of furnishing the city of Jersey City and the said townships of Van Vorst and Hoboken with a sufficient supply of pure and wholesome water.*"

The various items of the cost of constructing the works on this plan, will be seen by referring to the engineer's report,† to be $653,359. This estimate does not however include land, land damages and water rights; these, in the construction of the Croton aqueduct, amounted to something less than 3¼ per cent. of the whole cost of the work. As a pretty large proportion of the land, which will be necessary for this work, forms a part of the extensive marshes, lying on both sides of Hackensack river, and is generally esteemed of little value, it is be-

* Appendix B and C. † Appendix A.

lieved that a similar allowance, or four per cent. at most, will be sufficient in the present case.

This will amount to $26,134, which added to the estimates for work and materials, makes the sum of $679,493, the total cost of the works in complete operation, sufficiently extensive to supply a population of sixty-six thousand six hundred and sixty-six persons, with thirty gallons of water each per day.

The Commissioners could not with propriety, recommend the construction of works for procuring a supply of water, without examining the question, whether the benefits, which may be derived from their use, will repay the citizens for their cost. The benefits may be classed as follows: first, the direct income in the form of rents for the use of the water; second, increased security against losses by fire; third, improved cleanliness in streets, dwellings, &c., and a corresponding improvement in the health, comfort and habits of the population; and fourth, as the result of the foregoing, an improvement in the value of property. Of the amount of revenue to be derived from the water, and the value of the increased security against fire, which it will afford, some estimates have been made, and are herewith submitted. Of the pecuniary advantages of health, cleanliness and good habits, no estimate can be formed; but they may safely be set down among the most important which the works will produce.

Any estimate of improvement in the value of property would at present be entirely conjectural, therefore none is offered; but the Commissioners, nevertheless, suppose it will generally be conceded, that this is a consideration which ought to have an influence in deciding the question, whether water shall or shall not be introduced.

The estimate which has been made of the revenue to be derived from the water, was founded mainly upon the prices now charged for water in New York. These were made the basis of the calculation, because they have been fixed after several years experience, during which they have undergone some modifications, rendering them more productive, or more equitable in their operation: and also because Hoboken and Jer-

sey City, will to some extent, enter into a competition with New York, for water tenants. Higher prices than are charged there, would of course be impolitic, and lower could not at first be afforded; though every addition to the number of persons to be supplied, will tend to diminish the cost to each, and it will perhaps be found that the rates now proposed can in the course of a few years be considerably reduced. One thing in relation to the estimates presented, ought however to be kept constantly in mind; they are founded upon the present population and business, and leave entirely out of view the accessions to both, which may reasonably be expected to follow the introduction of an abundance of pure and wholesome water. They are intended to exhibit the results which might be expected, if the completion of the water works should entirely suspend improvement of every kind, and Hoboken and Jersey City should remain as they now are, for the next half century; nor is any estimate made of the income, which ought to be derived from the population, which will soon cover the southern extremity of Bergen hill, and the shores of Communipaw Bay.

Estimate of Revenue to be derived from the Water.

2,500	houses, (with 1 bath and 1 water closet,) at	$10—	25,000
400	extra water closets,	2—	800
	extra private baths,	2—	
30	public baths,	5—	150
200	back tenements, workshops, &c.,	5—	1,000
15	bakeries, 5 bbls. per day, each,	15—	225
1	brewery,		100
2	printing offices,	15—	30
33	steam engines, 10 horse power each,		3,300
6	slaughter houses,	15—	90
1	soap manufactory,		50
2	stone cutters,	25—	50
10	hotels,	30—	300
100	taverns, oyster houses, saloons, &c.,	15—	1,500
26	sea-going steamers, per annum,	50—	1,300
2	railroad stations,	50—	100
			$33,995

	Amount brought forward,		$33,995
15	locomotives,	100—	1,500
1	starch manufactory,		100
250	horses and cows,	2—	500
	ferries,		2,000
	water for vessels, per annum,		500
7	livery stables,	75—	525
3	omnibus stations,		25
200	street washers,	2—	400
250	houses, per annum,	10—	2,500
	Direct Income,		$42,045

To show the whole benefit which will be derived from the water, there must be added to the actual income, the saving in the cost of insurance upon $6,000,000, at one-third of 1 per cent.,	$20,000
Saving in expenses of fire department,	1,000
Saving in public cisterns, wells and pumps,	3,000
Total,	$66,045

For the purpose of ascertaining the effect of a full supply of water upon the security of property exposed to injury or destruction by fire, the Commissioners addressed a letter to Thomas A. Alexander, Esq., his reply to which will be found in the Appendix, marked E. This was accompanied by a printed copy of the rates of insurance charged by New York insurance companies on buildings and other property in New York, Brooklyn, Williamsburg, Hoboken and Jersey City.

It appears from this, that upon first class buildings, 15 cents per $100 more is charged in Jersey City, than in New York; and on buildings of the seventh class, the difference amounts to 50 cents per $100. As a pretty large proportion of the buildings in Hoboken and Jersey City are of wood, and belong in those classes which are charged at the highest rates, it is believed that the extra charge which would be made for insuring the whole of the property, liable to be destroyed by fire,

situated within their limits, would be at least 33⅓ cents per $100, or one-third of one per cent. upon the value. If the assessor's valuation of the property be taken as a basis for calculation, and to that be added the value of public buildings, not taxed, rail road property, ferry boats and other vessels in port, and other property which escapes the assessor's search, and from this amount be deducted the value of the land, the remainder will be the value of that which will be protected by a full supply of water. An *accurate* estimate of this is at present impractiable, but it is believed that $6,000,000, is a low, rather than a high valuation, and if one-third of one per cent. of its value, can be saved in the price of insurance, it will amount to $20,000 per annum.

This increased security is a consideration which affects every individual citizen, both in person and property; it makes no difference with the latter, whether he pays an office for insuring him, or whether he runs his own risk, it is equally an item of charge against the property; and many a valuable life would be saved, if an abundant supply of water, were always at hand in cases of fire, and ready for immediate use.

With respect to the value of the Croton water in preserving property from destruction by fire, the Croton Aqueduct Board in a report made in 1845, said, "one fact susceptible of the fullest demonstration, needs to be mentioned; it is, that every person who pays tax on real or personal estate, actually pays less money now than he did previous to the introduction of the water; this arises from the reduction of the rates of insurance. The tax to defray the interest on the Croton water debt, is 20 cents per $100, and the average rate of reduction on the rates of insurance, is 40 cents on the $100." And in a subsequent report it is repeated, "that the owners of property are actually paying less money than they would be obliged to pay were the Croton water not brought into the city; *for the following reasons.* First, allowing for the sake of argument, that the rates of insurance, are the same now as previous to the introduction of the water, the frequency of fires must have increased them at least 50 per cent. if we were destitute of the

abundant means to stay its ravages, which the city now possesses. Again, the expenses of the fire department, which previous to the advent of the Croton water, had increased to over $70,000 per annum, and in progressive ratio, at this day would undoubtedly have exceeded $100,000, have since that event decreased yearly, the appropriation asked for the current year, being $30,000 and the next year will be considerably less, as the board are informed."

As the apparatus for extinguishing fires is more abundant and the firemen more numerous in Hoboken and Jersey City, in proportion to the population and the property exposed than in New York, and as water is even less abundant here, than it ever was there, it is believed that 33⅓ cents is a smaller estimate, than a fair view of the case would warrant. At that moderate computation, however, the benefit to be secured by an abundant supply of water for the extinguishment of fires, alone would justify the expenditure of $333,333, even though the amount of property to be benefited, should never be increased.

To the saving in the cost of insurance, and in the expenses of the fire department, should also be added the whole amount of the expenditures in Hoboken and Jersey City, for public reservoirs, wells and pumps.

The annual cost of these, is now nearly $3,000, and this will go on increasing annually with the increase of population; unless they are superceded by some better means of obtaining and delivering to the inhabitants, a sufficient supply of water.

QUANTITY OF WATER.

The quantity of water which the Commissioners have supposed sufficient, will no doubt, by many, be considered unnecessarily large, and the plan which they recommend for obtaining it, too extensive and costly to be safely undertaken.

On this point, they cannot do better than repeat some remarks which were addressed to the citizens of Boston, in relation to the same matter. The Boston commissioners said, "we do not know of an instance where the largest provision has been made and the advantages flowing from it fairly tested, in which it

has failed to produce general conviction of its superior usefulness and entire satisfaction, that the extra cost of procuring an abundant, over an inferior supply, was a judicious expenditure. And we have, therefore, not the least doubt, that if the city adopt the plan of providing seven million five hundred thousand gallons per day, when the work is fairly brought into use and its benefits developed, there will be far more surprise, that any should have questioned its propriety, than that so large a supply was considered necessary." In this same city of Boston, many contended, that one million five hundred thousand gallons per day would be an abundant supply; and an engineer who was employed in making surveys and examinations for obtaining water, said in a written statement, presented to a committee of the Legislature of Massachusetts, that "ten or twelve years would elapse before two million one hundred thousand gallons per day would be likely to be consumed."

Yet in spite of these predictions, the daily consumption, during the hottest part of the last summer, reached eight million gallons per day, by a population of about one hundred and sixty thousand, or fifty gallons per day for each individual.

While the Croton aqueduct was in the course of construction, the chief engineer, in a report upon a plan for crossing Manhattan valley, remarked, "in making the estimate for four pipes, I have supposed an average time, in putting down the remaining pipes, of sixty years would elapse before the wants of the city will require the full operation of the aqueduct." But in the last annual report of the Croton aqueduct department, dated 31st December, 1850, only a little more than *eight* years after the first introduction of the water, this startling announcement appears: — *This Board* now warns the Common Council, and through it every citizen, *that the last drop of water which the works in their present state can supply, is now delivered in the city.*" The quantity now delivered by the Croton aqueduct, is thirty million imperial gallons per day, or sixty gallons for each individual of the whole population of the city of New York; and probably less than three-fourths of the whole number have the water furnished to them.

With these facts before them, the Commissioners would not feel warranted in recommending any plan not calculated to provide at least thirty gallons per day for each individual now requiring water, or which could not be extended to furnish that amount to any number which may be likely to require it hereafter. And this important result may be attained, whether the supply be taken from the Passaic or from the Morris canal. The quantity of water flowing in Passaic river, at Acquackanonck, at its lowest stage, must be at least one hundred and fifty million gallons per day. The only limit, therefore, to the supply from this source, will be the expense of raising and distributing it to the consumers. Should the Morris canal be resorted to, the supply must be stored in Greenwood lake. This is more than twice as large as Cochituate lake, which furnishes eight million gallons per day to Boston, and it receives the water which falls upon nearly three times as large an extent of country; so that, with similar arrangements, there is no doubt that more than twice as much might be procured from that source than is required to supply the city of Boston.

The Commissioners are directed to report "generally all such information connected with the object of their appointment, as they may deem important." The means of disposing of the water, after it has been received by the consumers and performed its office, is supposed by them, to be intimately connected with the work, and will be an important, if not indispensable appendage to the apparatus for bringing it to the consumers, if it is ever made to poduce all the benefits, sanitary and domestic, which a full supply of water ought to produce. They therefore suggest the propriety of adopting measures to obtain a well digested plan, which shall be adhered to in all time to come, for the drainage of the whole district proposed to be supplied with water—a plan which shall provide for draining not only streets but houses, areas and sinks in the lowest situations.

The Commissioners are not directly charged with the examination of this collateral subject, but conceive it to be one, which ought to receive immediate and careful attention, in

order that the plans for sewers may be considered, in connection with the arrangement of pipes for distributing the water. Much of the surface of Hoboken and Jersey City, even when sufficiently raised to be built upon, will be but little above the reach of ordinary spring tides; a peculiarity, which will render much care necessary in the arrangement of sewers and water pipes, in such manner, that neither may interfere with the operations of the other.

In situations, where sewers may be placed so low as to be entirely out of the reach of water pipes, laid at the ordinary depth, much attention to this matter is not required; but in the present case, it cannot be neglected without the risk of committing errors, which may require many years and large expenditures to correct, and cause much inconvenience and injury before the remedy is applied.

The Commissioners have not given this subject that degree of attention, which would warrant them in recommending any particular plan of sewerage; but they venture to remark, that if a branch of the Morris canal should be carried along the foot of Bergen hill, in the rear of Jersey City and Hoboken, and a well devised system of sewers should be constructed, reaching from the Hudson river to the canal, that probably they might be completely cleansed at every return of spring tides, by letting water into them from the canal, at or near the time of low water in the river.

In that way, a head of six or seven feet, and any desired quantity of water might be used for the purpose of producing a current sufficiently strong, to remove all accumulations of solid matter.

The necessity of early and careful attention to the drainage of towns and cities, and the importance of adopting and *adhering* to a well devised and comprehensive system in the construction of works for that purpose, are strongly insisted upon in a report to the Mayor and Common Council of New York, by the Croton Aqueduct Board, in 1847, the following extracts from which may prove interesting.

" The comfort and health of the inhabitants, particularly of that class of our population which is stowed away in crowded houses, depends, in so great a degree, on a sufficient supply of water, and a perfect system of drainage from cellars, yards and streets, that I am induced to call your special attention to this important subject."

" I therefore recommend the appointment of a commission that shall be charged with the investigation of the whole business of drainage from houses, yards and streets, that shall create a general system for the city, with explanatory remarks, and shall lay down in profile, on a map to be prepared for that purpose, all sewers with their dimensions, depths, &c., which it shall ever be necessary to construct. I believe the small number of sewers which have been built in the city were not laid down with reference to a general plan adapting them to the drainage of all the surrounding streets, houses and yards."

" The consequence is, that in some places the main sewer lays higher than the lateral sewers, and cannot receive and carry off all their contents."

" Errors of this description can be avoided, only by working after a general plan adapted to the undulations of the surface on which the city stands, and having reference to all its wants."

" This subject was deemed so important in England, particularly as respected the health of London, that a parliamentary commission was instituted, and composed of some of the most distinguished subjects of the crown, to inquire into the means necessary to drain and water populous towns and districts."

" The testimony taken by this commission is now before me. It occupies seven hundred printed folio pages, and was collected from every source, from which information could be derived. The experience of engineers, and of practical and scientific men, was brought to throw light on the inquiry, and to prove the unhealthy situation of such populous districts, as were not then effectually drained and supplied with water."

" The dictates of philanthropy in respect to the well being of

the poor and a common motive of self preservation from disease, appear to leave us, without excuse for longer delaying the commencement of a general system, after it has be enfully considered and well prepared by competent persons. To illustrate these opinions, it may be useful, that some facts should be gleaned from the report of the English commissioners. It was stated by distinguised medical men, who have had extensive practice in hospitals and dispensaries, that defective drainage, neglect of house and street cleaning, imperfect ventilation and a deficient supply of water, contribute to produce atmospheric impurities, which affect the general health and physical condition of the population, generating acute, chronic and ultimately organic diseases, especially scrofulous affections and consumption, in addition to the fevers, and other forms of disease, to which public attention has heretofore been directed."

"Another point dwelt upon in the report, is the insufficient use of sewers, for drainage of surface water only. The witnesses state, that for the most part, the usages at present prevailing, and the laws in force, have been framed with a view to the maintenance of the drainage of surface water only, and without reference to that system, which is now admitted by all the medicial witnesses, to be of the greatest importance to the public health, to the condition of the poorer classes, and the salubrity of their dwellings, namely, house drainage and sewerage, and the constant removal of all decomposing vegetable, or animal refuse, much of which might be effected by the proper application of water. As to the necessity of adopting a general plan before the work is commenced, the report mentioned above, furnishes proof from the experience of London, as well as the country towns. Some portions of that city cannot be effectually drained, for the reason, that the sewers first constructed, were not placed deep enough to carry off the water from other districts, where it was desirable to place lateral sewers. This is a serious evil, and in such cases renders impracticable all attemps to construct sewers, generally beneficial and useful."

Having now stated the results of their examinations respecting a supply of water, the cost of obtaining it, and the income and incidental advantages, which, in their opinion, may reasonably be expected from its use, the Commissioners take the liberty to remark, that the attention which they have been compelled to devote to the matter, has led them to the conclusion, that the health, personal comfort, and manufacturing and commercial prosperity of Hoboken and Jersey City, depend, to a very great extent, upon obtaining a plentiful supply of pure and wholesome water, for domestic and manufacturing purposes. If this is obtained, they will then possess one advantage over every other place in the immediate neighborhood of the commercial metropolis of America. By adding an abundance of this necessary of life, to the other advantages which the western shores of the Hudson now possess, a large proportion of those persons seeking residences, or situations for manufacturing establishments, near the busiest part of the city of New York, will be induced to select Jersey City or Hoboken, in preference to other places where good water cannot be obtained, and a rapid increase in population and wealth, will be the natural result. The very destitution now suffered, may, by compelling the construction of works for procuring water at this early stage of their growth, eventually prove a fortunate characteristic of their situation.

The proposed work will, it is true, be a costly one to be undertaken by the present population, although an exceedingly cheap one compared with other works constructed for the same purpose in other places. The city of New York, with a population of about three hundred thousand when the work was begun, built the Croton aqueduct at a cost of $13,000,000, or about $43 for each inhabitant. And Boston built the Cochituate works at an expense of $4,000,000, or about $35 for each of the one hundred and fifteen thousand individuals that constituted the population at the time they were commenced; and neither of those cities could be induced to give up the comforts and advantages derived from the use of the water they now receive, and return to the former impure

and scanty supply, for ten times the sums which the works have cost.

A careful analysis of the engineer's report, which the Commissioners submit with full reliance upon its correctness, shows, that if the number of persons requiring water should amount to seventeen thousand five hundred, the whole cost of constructing the works would amount to about $37.50 for each individual, or a little more than was expended for each in Boston, and a little less than the cost for each in New York.

But there is one material point in which the work proposed by the Commissioners differs from those of New York and Boston. There, the sources of supply are sufficiently elevated to allow the water to flow, by its own gravity, into the distributing reservoirs, and here it must be pumped the whole height required. The cost of pumping for each person, if estimated by the performance of numerous pumping engines in Great Britain, will not exceed seven or eight cents per annum, and if the actual cost of pumping at the Spring Garden water works, at Philadelphia, be taken as the basis of the calculation, it will not be much higher; but if the estimate which was made of the expense of pumping for the supply of Boston, be a correct one, the cost of raising thirty gallons per day for each individual, may reach twelve cents per annum, or one cent per month. This expenditure will be constant, and in order to present a fair estimate of the cost of the works, a sum ought to be added to the above, the income from which, at six per cent. per annum, would defray the current expenses of raising the water.

As twelve cents per annum is believed to be a liberal estimate—one that will not be likely to be exceeded under ordinary circumstances—a capital of two dollars, contributed by each consumer, would constitute a sufficient fund to keep the pumping apparatus in constant operation. And this, added to the capital required for construction, would make the cost of the complete work to each individual of the population $39.50 to $40. The interest upon this sum, with the cost of repairs and management, and a small addition to form a sinking fund

for the final redemption of the water debt, should make up the amount of rent to be paid for the use of the water.

The Commisioners now close their labors, with the remark, that the want of water here, is probably as pressing as it ever was in any place that adopted measures for procuring a supply; and, so far as they are informed, the construction of works for supplying water to towns and cities, has always been followed by the most satisfactory results, nor does there appear to them any reason to doubt that great pecuniary advantage and entire satisfaction among all parties concerned, would follow the introduction of an abundant supply of pure and wholesome water into Hoboken and Jersey City.

All which, is respectfully submitted.

JOHN D. WARD,
D. S. GREGORY,
A. L. VAN BOSKERCK,
EDWARD COLES.

Jersey City, 8th December, 1851.

APPENDIX A.

REPORT

UPON THE DIFFERENT PLANS OF SUPPLYING

JERSEY CITY AND HOBOKEN WITH WATER.

By WILLIAM S. WHITWELL,

CIVIL ENGINEER.

To the Chairman and Board of Water Commissioners of Jersey City and Hoboken:

GENTLEMEN,—Having completed the surveys and estimates for supplying Jersey City and Hoboken with water, the result is presented in the following pages.

In your letter of instructions, I am desired to make such surveys, plans and estimates, as will enable you to decide upon the relative value of the different sources from which it has been proposed to obtain the required quantity of water, and to report upon such of them, as in my opinion deserve investigation.

You have also directed, that the source from which the supply should be taken, should be capable of furnishing daily, at least seven million five hundred thousand imperial gallons for daily consumption, and that two million might be assumed as sufficient for the prospective wants of your citizens for some years.

It was very evident, that the quantity here named, could be obtained only from the largest bodies of fresh water in your vicinity, and my attention was therefore more immediately directed to those places, embracing the Morris canal and the Passaic river, as sources of supply.

The principal plans and sources of supply to which you have specially directed my attention, in your letter of instructions, will be briefly stated, and then described in the following order:

First.—Taking the water from the Passaic river, above Belleville, to conduct it through the ridge, known as Barbadoes Neck, by a tunnel, thence in iron pipes to a receiving reservoir at the foot of Bergen hill, from which it would be pumped by steam power to the distributing reservoir.

Second.—From the canal above the mills at Paterson, thence in iron pipes to a reservoir on Bergen hill.

Third.—From the Dundee dam, a few miles below Paterson, pumping the water by water-power to some adjacent hill, from which it would be conveyed in iron pipes to Bergen hill.

Fourth.—From the Morris canal at Bloomfield, thence in iron pipes to Bergen hill.

Fifth.—From Rockland lake, thence by a brick conduit to the distributing reservoir on Bergen hill.

Sixth.—By gathering the water on the western slope of Bergen hill in drains, leading to a reservoir at the base, and elevating it by steam-power to the reservoir above.

Seventh.—The several small streams and springs found on the ridge of high ground, lying between the Passaic and Hackensack rivers, and having conveyed the water in iron pipes, across the marsh to a receiving reservoir at the base of Bergen hill, thence to pump it by steam power to the reservoir on the summit.

To these modes of supply, I have added another which suggested itself—that of pumping the water direct from the Passaic river at Belleville, to a reservoir on the summit of Barbadoes Neck, from which place it would descend by gravitation in iron pipes to the reservoir at Bergen hill.

The advantages of this plan appeared so obvious, that a survey was made, and the estimate will be found with the others.

The examination of so many plans has necessarily extended the surveys beyond what the apparent exigencies of the case seem at first to have demanded; this was done in accordance with your advice and instructions, in order to remove partialities for particular projects, and to settle, beyond a doubt, the correctness of your final decision.

Before beginning the surveys, an examination was made of that part of Bergen hill, north of the Five Corners, for the purpose of selecting a site for a distributing reservoir. By the aid of the levels and plan furnished by Messrs. Clerk & Bacot, it was found that the choice would not be confined to one or two plans; but that several sites could be obtained, varying in elevation from one hundred and twenty to one hundred and thirty-five feet above high water at Jersey City. One of these, on the estate of J. Van Wagenen, Esq., and west of the road, was selected as the point at which the various lines of the survey should terminate, and an elevation of one hundred and twenty-five feet was assumed as the top water line of the reservoir.

In all the calculations for the size and discharge of pipes, Prony's formula, $Q = 38{,}116 \sqrt{D^5 \frac{H}{L}}$ has been used.

The different plans will now be described.

I.—FROM THE PASSAIC RIVER, BY A TUNNEL THROUGH THE RIDGE.

Length, six miles one thousand five hundred and sixty-one feet.

By this plan, it has been proposed to tap the Passaic river at some point above Belleville, and leading the water through the ridge bordering the river, and known as Barbadoes Neck, by a tunnel, to convey it in iron pipes over the marsh and under the Hackensack river, to a receiving reservoir at the

foot of Bergen hill, thence to pump it by steam-power to the distributing reservoir.

After a very thorough examination of the ridge, for a distance of six miles above Newark, by a reconnoisance and numerous surveys, to determine the most eligible place for the tunnel, that part traversed by a line between the Felt factory on the Passaic, about one mile and one-quarter above Belleville, and the estate of George Kingsland, on the marsh, was selected.

The line of the tunnel enters at a depth of one hundred and ten feet below the highest point of the ridge. Its length is four thousand six hundred feet, with short open cuts at each end, amounting to fifty thousand cubic yards of excavation.

The drift and shafts would be in red shale, of very easy excavation,—this has been very satisfactorily determined from the shaft of over two hundred feet in depth, and the tunnel of one thousand seven hundred feet in length, excavated some years since for mining purposes.

From the fact of this tunnel being in rock, from the small amount of open cutting at its faces, and the probability of meeting with much less water than upon any other line, it has been adopted as the one upon which the estimate has been made.

From the eastern end of the tunnel, the line was continued across the marsh, passing just north of Snake hill to the edge of the hard ground at the foot of Bergen hill, selected as the site for the receiving reservoir.

At the Passaic river a large receiving reservoir will be constructed, into which the water will enter through self-acting tide gates, at high tide, and will supply the pipes until the return of the next tide shall again open and re-fill it to its former level.

From the river to the east end of the tunnel, the descent will be at the rate of four inches to the mile.

The tunnel will terminate here in a pipe house, with openings for three pipes, only one of which will be needed at the present time—the size of this pipe should not be less than thirty inches.

From the pipe house the pipe will pass the marsh to the Hackensack river, thence under that river by a flexible ball and socket joint-pipe to the east side, and from thence to the receiving reservoir at the foot of Bergen hill.

The bottom of the pipe, at its entrance into the reservoir, will be five and one-half feet below the level of the marsh.

The salt marsh, lying between Bergen hill and Barbadoes Neck, is from three and one-half to four miles in width. It is covered with a thick turf, under which is a mud so soft that the sounding rod sinks by little more than its own weight, and underlying the mud is a hard clay. To ascertain the depth of the mud and turf, excavations and soundings were made upon three different lines, every thousand feet. The turf was found to vary in depth from two to four feet, and the soft mud from nine to nineteen feet, averaging about fourteen feet.

Under such circumstances, to preserve the perfect stability of the pipe, it would become necessary to prepare a foundation by driving piles to the hard clay and capping them with timber; upon these caps the pipe would rest at intervals of eight and one-half feet.

The cost of excavation and laying cannot be calculated with much accuracy, but it will be rendered very expensive from the additional expense of pumping water.

The receiving reservoir should be constructed to hold at least the run of twelve hours, or one million of gallons.

From this reservoir, the water will be pumped through a twenty inch main, of two thousand four hundred feet in length, to the distributing reservoir above.

II.—FROM THE CANAL AT PATERSON.

Length, fourteen miles one thousand six hundred and sixty feet.

The only survey necessary on this line, was to measure the distance between the canal and the railroad station at Paterson, from thence the remaining distance was obtained from the established measures of the railroad.

The pipe, after leaving the canal, will follow the line of the Paterson railroad, nearly to its intersection with the New Jersey railroad, passing the Passaic, the Hackensack, and several smaller streams, and will then discharge into a distributing reservoir, eighty-one feet above high tide.

The level of the water in the canal, above tide, according to the statement of Mr. Colt, the proprietor of the water-power, is one hundred and six feet.

To discharge two millions of gallons in twenty-four hours, under a head of twenty-five feet, will require, with the allowances for bends and incrustations, a pipe of twenty-four and a-half inches.

At the time of my examination of this line, in the latter part of September, no water was running over the dam of the Passaic, the factories were using all the water passing in the canal, and complaints were made, that even that was insufficient to keep all the machinery at work.

There can be no doubt, that the abstraction of so large a quantity of water, as might be eventually required for your purposes, would seriously interfere with the manufacturing interests of Paterson, and involve you in constant and troublesome litigation. This fact, in connection with the cost of the line, and the low elevation at which the water would be delivered on Bergen hill, being thirty-nine feet below the minimum height desired, is sufficient to prevent its adoption.

III.—FROM THE DUNDEE DAM.

Length, ten miles four thousand two hundred and thirty-two feet.

This plan contemplates taking the water from the Passaic river, at the Dundee dam, a few miles below Paterson, and having pumped it by water-power to the top of an adjacent hill, conveying it in iron pipes, along the line of the Paterson railroad to Bergen hill.

The survey of this line was commenced at the dam, and carried to Post's hill, a distance of four thousand six hundred

feet, where a site for a reservoir can be obtained, at an elevation of one hundred and fifty feet above the river; from thence it was extended to the Boiling Spring station, on the Paterson railroad, from which place the distances of the railroad were assumed as correct.

Assuming the head under which the pipe will discharge, at twenty-five feet, and making the usual allowance for bends and incrustations, this line will require a twenty-three inch pipe to discharge two millions of gallons in twenty-four hours.

Should this plan be adopted, it would be expedient to purchase the whole Dundee property, and having rebuilt the dam eight or ten feet higher, and carried a canal some distance down the bank of the river, a fall of twenty feet could be obtained, by which the water could be pumped to the height required.

This would involve the expenditure of so large a sum, that, when we add the amount required to defray the damages incurred by extensive flowage, and the already high cost of the line, a decision in favor of this project cannot be expected.

IV.—FROM THE MORRIS CANAL AT BLOOMFIELD.

Length, eight miles three thousand three hundred and seventeen feet.

By this plan it is proposed to take the water from the Morris canal at or near the inclined plane at Bloomfield, and to convey it in an iron pipe, thence to the distributing reservoir.

The survey was commenced at the inclined plane, and after running in a pretty direct line to Belleville, was connected with the line starting from that point, and passing north of Snake hill to the distributing reservoir.

The height of the canal at the inclined plane, is one hundred and seventy-four feet above tide.

To discharge into the distributing reservoir the required two millions, at an elevation of one hundred and twenty-five feet

above tide, will allow a head upon the pipe of forty-nine feet, and the formula for this head, without the usual allowance for bends and incrustations, gives a diameter of eighteen and one-half inches ;—the estimate will be made for a pipe of twenty inches.

To provide against the occasional rupture of the banks of the canal, or a short supply of water, it will be necessary to construct a large storing reservoir, containing a supply for at least two weeks. This should be divided into two compartments, into one of which the water should be drawn from the canal, and after having remained a sufficient time for the impurities to settle, drawn off into the other, from which it would be conveyed by the pipes to the distributing reservoir.

The ground at the inclined plane is not adapted for a larger reservoir than one to contain twenty-five and a-half millions of gallons. Whenever the consumption of water should much increase, it would become necessary to construct others in the neighborhood.

One great advantage of this plan over all othes, is in having a source sufficiently high to elevate the water to Bergen hill by the power of gravitation alone; but when the estimated cost of the line is added to the sum of $250,000, demanded by the Canal Company for use of the water, the aggregate amount will be found sufficient to prevent a favorable comparison with other lines.

V.—FROM THE PASSAIC RIVER AT BELLEVILLE.

Length, six miles one thousand one hundred and eighty-five feet.

By this mode, it is proposed to admit the water from the river at Belleville, by an open cut of four hundred feet in length to the pump well, and from thence to pump it through a rising main of twenty inches in diameter and two thousand two hundred feet long, to a reservoir or stand pipe on the top of the hill.

The elevation of the hill is one hundred and fifty feet above high water.

From the reservoir, the pipe will pass to the marsh on the east side of the ridge, crossing the marsh to Bergen hill by either of the routes marked upon the plan:

By the line north of Snake hill, and passing under the Hackensack river by a flexible pipe, or keeping near the turnpike, and crossing the river at the turnpike bridge, on piers constructed for that purpose.

By the former lines the distance would be two thousand feet shorter than by the latter, but the advantages of crossing the river in a mode admitting of easy access to the pipe for repairs, is a sufficient reason for giving the preference to the latter line.

By the proposed plan for crossing the river, piers will be constructed by the side, but entirely distinct from the turnpike bridge. Upon these piers the pipes will rest enclosed in an air-tight wooden box, forming a perfect protection from the cold of the severest winter.

At the draw, the pipe protected by the box, as far as the low water mark, will pass down on one side, and after crossing at a depth below the reach of vessels, will pass up and connect with the main pipe on the other side.

To guard against the diminished capacity of the pipe by the collection of sediment, and to allow of its removal, this part of the pipe, called the "syphon," is increased to thirty inches.

On the outside of the piers, a line of guard piles, connected by oak fender caps and attached to the turnpike bridge by long stays or girders, will be placed as a protection for the boxes, from the blows of vessels or other large floating bodies.

Opposite to the village of Belleville and east of the road, very favorable ground may be found for the location of the engine house, engine, and pumps.

On the top of the ridge, the surface is level for a sufficient distance, either north or south of the road, to allow a selection from a number of sites, where a reservoir capable of holding from two to forty millions of gallons, may be constructed at an expense unusually small.

Should it be found that the cost of the work is too great for the present means of the two places, the expense of a reservoir at this place may be avoided for the present, by pumping into a stand pipe of thirty or forty feet in height; by which means the shock consequent upon pumping into a long line of pipe would be obviated, and the flow of the pipe from the additional head considerably increased.

The pipe proposed to be laid from the top of the hill at Belleville to the distributing reservoir, will be twenty inches in diameter.

This is calculated to give two millions in twenty-four hours. If, therefore, the pumps were worked only twelve hours per day, but one million of gallons would be discharged; but as this may be sufficient for the present wants of the inhabitants, the reservoir would not be needed, until the consumption became so large as to require the full run of the pipes for twenty-four hours, in which case the reservoir would become indispensable.

RESERVOIRS.

Reservoirs act an important part in a complete system of water works, and whenever they can be obtained at a reasonable expense, should always be provided.

They serve to maintain a constant head upon the pipes, and a large body of water in reserve, in case of fire, or accident to the pipes, or machinery.

The main distributing reservoir of a city, should be situated as near to the centre of consumption, and should have as large a capacity as the nature of the ground will permit. In the city of Boston, so important was a reservoir considered on the high ground in the centre of the city, to maintain a constant head upon the pipes, that an expense of $450,000 was incurrred, to secure a basin of only three millions of gallons,—without it, the large draught taking place at times in the lower part of the city would have emptied the pipes on the high ground, when now, a head of twenty-five feet above the street is main-

tained, and the hydrants, which to a great extent, have superseded the fire engines, would have lost half their efficiency.

The situation and elevation of Bergen hill is such, as to afford the site for a convenient, cheap, and capacious distributing reservoir, which may be located a little west and intermediate of Jersey City and Hoboken, and only one mile and three-quarters from either place; it will occupy about thirteen acres, and, with a depth of ten feet, will contain nearly thirty million of gallons, a supply sufficient for fifteen days, when the consumption is two millions per day.

The banks will be four feet above the top water line, that being assumed at one hundred and twenty-five feet above high water, with slopes of one and a-half horizontal to one vertical on the inside, and two horizontal to one vertical on the outside. A broad wall of puddled earth will be built in the centre of the bank, commencing four feet below the surface and extending to the top water line. A coating of puddled earth will cover the bottom. The inside slopes will be gravelled, and lined with bricks laid upon their edges, in cement, for a depth of six feet, or as far as the fluctuation of the water takes place. The outside slope will be sodded, and the top gravelled. The reservoir will be divided by a wall of brick masonry into two compartments, having a gate and weir for admitting the water from one to the other, by which arrangement one division may be cleaned, while the other continues to supply the pipes. The influent pipe and the effluent and drain pipes will be so arranged, that the one will enter the bank, and the other two will pass out through brick galleries communicating with stop-cock chambers inside the bank. The whole ground will be enclosed by a wooden fence.

The reservoir on Barbadoes Neck, though intended mainly to avoid pumping directly into the supply pipe, will serve as far as its capacity will allow, as a storing reservoir and as a place of deposit for the impurities of the water, which otherwise might enter and remain in the pipes. It is intended to be made two hundred feet square, and with a depth of eight feet of

water, will contain nearly two million of gallons. It may be made nearly all in excavation; in which case the sides and bottom, after being covered with puddled earth, will be faced with bricks laid in cement.

The influent, effluent, and drain pipes will be arranged in a similar manner to those of the Bergen hill reservoir, and the ground occupied by the reservoir will be enclosed by a wooden fence.

It may be found, that at certain seasons of the year the river will bring down so much sediment, that it may become necessary to erect filtering beds for the purification of the water. Should this be the case, this is the place for their location; and for this purpose, as well as for the enlargement of the reservoir at some future time, it would be prudent to secure a lot of land sufficient for the purpose.

It will be seen from the table of estimates, that the actual cost of this plan is only $653,359.01; but, in order to compare it with the other plans, a capital sum is added, the interest of which will pay the cost of running the engine.

PUMPING.

Pumping water by steam has, until very lately, received little attention in this country, and has been performed by either the high pressure engine, or the low pressure condensing engine of Boulton & Watt; but, in England, in the county of Cornwall, where immense quantities of water are raised, in working the mines, the Boulton & Watt engine, which, for many years, had been in use, has, during the last thirty years, been so modified and adapted to the particular duty of raising water; that with the same quantity of fuel, its performance has been increased three-fold, and, under its present form, has received the distinctive name of the Cornish engine.

The improvements may be described, as consisting principally "in carrying out the principle of expansion, by using the steam of a higher pressure, and cutting it off earlier in the stroke; in a considerable extension of the boiler surface, in

proportion to the quantity of water evaporated, and fuel consumed; in a more careful management of the combustion; in improvements in the minor details of the engine, and the mechanical construction of the working parts, particularly the pump work, whereby the loss of power by prejudicial resistances, has been much lessened; and in the exercise of the most scrupulous care in guarding against waste or loss of heat by any means."

From accurate reports, kept by the engineers of the mines, we are enabled to estimate the value of these improvements, and to ascertain the amount of duty performed at any particular time.

In 1812–'13–'14, the average duty was twenty millions of pounds raised one foot high, with ninety-four pounds of coal, or one bushel. In 1821 it was 28,300,000; from 1821 to 1838 it increased to fifty millions; and in 1843 it rose to sixty millions,—the greatest duty this year being 107,500,000 pounds.

At this time there are only three engines upon this principle in this country; two of these are now working at the mines in Pennsylvania, one of which was imported from Cornwall about two years since as a model. The third engine has been built during the last summer for the water-works at Buffalo. It is much regretted, that no return of the work performed by the first two has been received, and the latter having been very recently erected, has not yet been fairly tested.

From a report made to one of your board, E. A. Stevens, Esq., during his visit to England, by George A. Phipps, Esq., an English engineer, employed by Mr. Stevens to collect information on this subject, I make the following extract:—

"From an experience of many years, from the three last of which the following is derived, my friend, Mr. Wicksteed, of the East London water-works, informs me that the greatest economy has resulted from the use of the Cornish engine, and, indeed, this is a fact notorious to us all. Taking the years 1848, 1849, and 1850, it appears that the average duty—that

is the pounds of water raised one foot with a bushel of coal (88 lbs.)—of three of the engines was as follows:—

NAME OF ENGINE.	Lbs. raised one foot with 88 lbs. Coal.	Consumption per horse power per hour.
The best of the Boulton & Watt engines, . . .	25,444,884	$6\frac{3}{4}$ lbs. coal.
The first Cornish engine, erected in 1839, . . .	55,932,542	3 lbs. coal.
The second Cornish engine, erected in 1847, . . .	60,175,152	$2\frac{3}{4}$ lbs. coal.

"Mr. Wicksteed has also shown me his books, from which it appears that the cost of attendance and repairs to the Cornish engine does not exceed that of the Boulton & Watt engines."

The examination of the duty performed by these engines, compared with that of others, and the above testimony, has induced me to recommend this engine as the one combining the greatest economy, simplicity, and adaptation to the work required.

The duty of the engine is to raise two million gallons one hundred and fifty feet high, in addition to that of overcoming the friction due to the pipe.

To pass two million gallons, or three hundred and twenty-two thousand five hundred and eighty-one cubic feet, through a twenty inch pipe, two thousand two hundred feet long, in twelve hours, will, according to the formula, require a head of 6.5 feet.

We shall then have to raise two million gallons 156.5 feet in twelve hours; this is equal to four hundred and forty-eight feet per minute; then 448 x 156.5 x $62\frac{1}{2}$ lbs. will be equal to 4,382,000 lbs. raised one foot high per minute, to this should be added one-fifth for friction of pumps and machinery, and the amount to be raised will be 5,258,400 lbs. raised one foot high per minute; 5,258,400 lbs. divided by 33,000 lbs., the standard for a horse-power will give 159.3,—say 160 horse power, as the power required for the engine.

From the report of Mr. Phipps, I extract an estimate made for a different height, and the same quantity of water, and based upon the table given before, in which three pounds per horse-power per hour was the amount of coal used.

"For an engine to raise two million gallons in sixteen hours, two hundred and sixty horse power:—

Two thousand and thirty-three tons coal, at $4,	$8,132 00
Labor,	3,416 00
Repairs,	292 80
Oil, rope-yarn, &c.,	1,464 00
Amounting, per annum, to	$13,304 80

Taking now the proportion due to an engine of one hundred and sixty horse power, or eight-thirteenths, we shall have $8,187 60, as the cost of raising two millions of gallons 156.5 feet.

Mr. Jervis, in his report to the water commissioners of Boston, in 1845, estimated the cost of doing the same amount of work at $9,339 23.

The cost of working sixteen hours, is greater, in proportion, than for twelve hours, so far as labor is concerned. I shall, therefore, reduce this item in the following estimate.

Cost of raising two millions of gallons one hundred and fifty-six and one half feet high in twelve hours, one hundred and sixty horse-power, at three pounds per horse-power per hour, will amount, in three hundred and sixty-five days, to nine hundred and thirty-eight tons coal, at four dollars per ton,

			$3,752 00
Engineer, 365 days, at $2 00	-	$730 00	
Assistant engineer, at 1 50	-	547 50	
Two firemen, - at 1 00	-	730 00	
			$2,007 50
Oil, hemp, tallow, &c., per Phipps' estimate,	-		900 80
Repairs on machinery and buildings 2½ per cent. on 65,000,	-		1,300 00
Total cost of raising two million gallons,			$7,960 30
Say, the interest at six per cent. on a capital of			$133,333 33

To pump one million gallons, all that will be required for several years, will require the engine to be worked but six hours per day; and in this case, the labor may be so reduced that the cost of pumping this amount will not exceed five thousand dollars.

It should be understood, that this estimate is applicable to the time, when experience has enabled the engineer to work the engine with the greatest economy of fuel and the least outlay for repairs.

The estimated cost of the several lines will be seen from the following summary, taken from the tables of estimates, in detail, and appended:

No. 1. From the Passaic, by a tunnel, - -	$1,049,868 44
No. 2. From the canal at Paterson, - -	904,841 07
No. 3. From the Dundee dam, - - -	933,921 91
No. 4. From the Morris canal, - - -	969,396 96
No. 5. From the Passaic at Belleville, -	786,692 34

My examinations have led me to the conclusion, that the plan which I would recommend for your adoption, is, that of pumping the water direct from the Passaic at Belleville, to the reservoir on the top of Barbadoes Neck; and the following reasons may be given in its support:

First. By this mode of supply, the works may be made of a size adapted to the present wants of your citizens, and enlarged whenever the increase of the population requires.

Second. By placing the lifting power at the Passaic, instead of at the foot of Bergen hill, the conducting pipe is reduced from thirty to twenty inches, a reduction of expense not only in the first cost, but which applies to the period when a second pipe will be needed.

Third. In crossing the marsh, upon this plan, the pipe may be laid upon the top of the turf, and the expense and inconvenience of laying beneath the surface avoided, a feature inherent to all plans in which the lifting power is at the foot of Bergen hill.

Fourth. The pipe in crossing the Hackensack river, may pass by the side of the turnpike bridge, and in such a manner as to be accessible whenever repairs or renewals require.

Fifth. It is shorter than any other line, except that north of Snake hill, and consequently the cost of repairs and renewals is proportionably less.

Sixth. The expense is nearly two hundred thousand dollars less than that of any other plan by which the water is delivered at the same height.

Very respectfully,

Your obedient servant,

WILLIAM S. WHITWELL.

Boston, December 9th, 1851.

ESTIMATES.

BARBADOES NECK RESERVOIR.

21,000	cubic yards of excavation,	at 15c. -	$3,150 00
4,000	" " puddled earth,	at 50c. -	2,000 00
4,000	" " gravel,	at 50c. -	2,000 00
340,000	bricks on bottom and sides,	at $20, -	6,800 00
	Pipe, chambers and galleries,	- -	1,500 00
	Pumping water for puddling,	- -	1,250 00
			$16,700 00

BERGEN HILL RESERVOIR.

40,000 cubic yards of embankment,	at 25c.	$10,000	—
38,000 " " puddled earth,	at 50c.	19,000	—
4,000 " " soil,	at 25c.	1,000	—
4,000 " " gravel,	at 50c.	2,000	—
12,000 " " excavation and in bank,	at 12c.	1,440	—
8,000 square yards of sodding,	at 15c.	1,200	—
790 cubic yards of brick in division wall,	at $7,	5,530	—
681 cubic yards of brick in lining,	at $7,	4,767	—
500 running feet of coping,	at $2,	1,000	—
2,000 cubic yards of rip rap wall,	at $1.50,	3,000	—
Pipe, trench, and stop-cock chambers,		1,500	—
Pumping water for puddling,		2,000	—
4,000 feet of fence,	at 40c.	1,600	—
		$54,037	—

DISTRIBUTION FOR JERSEY CITY.

3,600 feet of 26 inch pipe, -	at $6.50,	$23,400	—
8,575 " 20 " -	at 5.50,	47,162	50
7,320 " 12 " -	at 2.50,	18,300	—
50,760 " 6 " -	at 1.25,	63,450	—
2 " 26 inch stop cocks,	at 300.00,	600	—
3 " 20 " "	at 250.00,	750	—
15 " 12 " "	at 75.00,	1,125	—
74 " 6 " "	at 35.00,	2,590	—
140 fire hydrants, with pipes, bends, boxes, &c., - -	at 60.00,	8,400	—
87,848 lbs. branches, - -	at 0.03,	2,635	44
		$168,412	94

DISTRIBUTION FOR HOBOKEN.

4,650 feet of 16 inch pipe,	-	-	at $4.50,	$20,925 —
3,850 " 12 "	-	-	at 2.50,	9,625 —
13,100 " 6 "	-	-	at 1.25,	16,375 —
4 " 16 inch stop cocks,	-		at 125.00,	500 —
5 " 12 " "	-		at 75.00,	375 —
22 " 6 " "	-		at 35.00,	770 —
60 fire hydrants with pipe, bends, boxes, &c.,	-	-	at 60.00,	3,600 —
45,260 lbs. branches,	-	-	at 0.03,	1,357 80
				$53,527 80
Providing yard, buildings, proving press and other expenses,	-	-	-	6,000 —
Jersey City distribution,	-	-	-	168,412 94
Total cost of distribution,	-	-		$227,940 74

I.—FROM THE PASSAIC RIVER, BY A TUNNEL THROUGH THE RIDGE.

Receiving reservoir and gates at Passaic river,	-		11,540 —
4,600 feet of tunnel,	-	at $13 per foot,	- 59,800 —
608 " shafts,	-	at 9 "	- 5,472 —
50,000 cub. yards of excavation, at 25c. per yard,			12,500 —
Coffer dam at river,	-	-	- 1,000 —
Engines and expense of pumping,	-	-	- 10,000 —
Powder,	-	-	- 2,000 —
Candles and lamps,	-	-	- 2,500 —
Lumber for shafts, and coverings for engines,			- 2,000 —
Tools, including drills and coal for smith shop,			- 4,500 —
Superstructure and miscellaneous expenses,			- 10,000 —
Cost of tunnel,	-	-	$121,312 —

Carried forward, - - -		$121,312 —
22,690 feet 30 inch pipe, at $8.50,	$192,865	
Excavation and pile foundation, at $4,	90,760	
		283,625 —
Staging for putting down flexible pipe under Hackensack river, 73 piers, - - at $130,	9,490	
Removing the same, - -	1,500	
900 feet of 30 inch flange pipe, extra thickness, at $23 per foot, -	20,700	
27 flexible ball and socket joints, at $457, - - - - -	12,339	
Putting down pipe, - -	3,500	
		47,529 —
Pile bridges over Ned's & Pinhorne's creeks,		1,300 —
2,394 feet of 20 inch rising main, at $5, -		11,970 —
Receiving reservoir at foot of Bergen hill, -		20,500 —
Engine house, engines and pumps, - -		65,000 —
Distributing reservoir on Bergen hill, - -		54,037 —
Distribution, as per estimate, - - -		227,940 74
Contingencies, including superintendence, ten per cent. on $833,213.74, - - -		83,321 37
		$916,535 11
To this amount should be added the capital, the interest of which would pay the cost of running the engine, - - -		133,333 33
		$1,049,868 44

II.—FROM CANAL AT PATERSON.

73,784 feet of 24½ inch pipe, at $6 per foot,	$442,704 —

Carried forward, - -		$442,704 —
Crossing the Passaic.		
21 Piers, at $150, - -	$3,150	
120 feet 30 inch pipe for syphon, at $9.50, - - -	1,140	
Putting down syphon, - -	2,000	
353 feet of box for pipe, at $5.00,	1,765	
		8,055 —
Crossing Berry's Creek.		
11 Piers at $100, - -	1,100	
90 feet of 30 inch pipe for syphon, at $9.50, - - -	855	
161 feet of box for pipe, at $5, -	805	
Putting down syphon and dredging,	1,000	
		3,760 —
Crossing Hackensack river.		
92 Piers, including guard piles and fender caps, at $150 per pier,	13,800	
120 feet of 30 inch pipe for syphon, at $9.50, - - -	1,140	
1,658 feet of box to enclose pipe, at $5,	8,290	
Putting down syphon, - -	2,000	
		25,230 —
Crossing Pinhorne's creek, - - -		250 —
Distributing reservoir on Bergen hill, as for other lines, - - -		54,037 —
Distribution, - - - -		227,940 75
Contingencies, superintendence, &c., ten per cent. on $761,976.74, - - -		76,197 67
		$838,174 41
To this should be added the capital, the interest of which is the amount of rent ($4,000,) charged for the water, - -		66,666 66
		$904,841 07

III.—FROM THE DUNDEE DAM.

Pumps, pump house and inlet well at the dam,		$16,000 —
4600 feet of 20 inch rising main, at $5 per foot,		23,000 —
Reservoir on Post's hill,		16,000 —
52,432 feet of 23 inch main, at $5.75,		301,484 —
Crossing Berry's creek, as per last estimate,		3,760 —
Crossing Pinhorne's creek,		250 —
Crossing the Hackensack river,		25,230 —
Distributing reservoir on Bergen hill,		54,037 —
Distribution,		227,940 74
Contingencies, including superintendence, 10 per cent. on $667,201.74,		66,720 17
Cost of Dundee property, rebuilding dam, damages for water flowage, &c., say		200,000 —
		$934,421 91

IV.—FROM THE MORRIS CANAL.

Subsiding reservoir at Bloomfield,		65,179 50
45,617 feet of 20 inch main, at $5 per foot,		228,085 —
Crossing Davis' mill pond,		1,000 —
Crossing the Passaic.		
291 feet of pile bridging at $10,	2,910	
80 ft. of 30 in. pipe for syphon, at $9.50,	760	
Putting down and dredging,	3,500	
261 ft. of pine box to enclose pipe, at $5,	1,305	
		8,475 —
Crossing the Hackensack, by bridge.		
58 piers with guard piles and fender caps, at $201 per pier,	11,658	
1024 feet of pine box to enclose pipe, at $5 per foot,	5,120	
180 feet of 30 inch pipe for syphon, at $9.50 per foot,	1,710	
Putting down and protecting pipe,	3,000	
		21,488 —
		$324,227 50

Carried forward, - -	$324,227 50
22,521 feet of pile foundation, at $2, - -	45,042 —
10 stop cocks, 20 inch, at $250, - -	2,500 —
5 air cocks, at $50, - - - -	250 —
Reservoir on Bergen hill, - - -	54,037 —
Distribution, - - - - -	227,940 74
Contingencies, including superintendence, 10 per cent. on $653,997.24, - - -	65,399 72
Amount charged by Morris Canal Co. for water,	250,000 —
	$969,396 96

V.—FROM BELLEVILLE BRIDGE.

Inlet cut and pump well at Passaic river, -	$4,780 —
Engine house, engines and pumps, -	65,000 —
29,055 feet of 20 inch main, at $5 per foot, -	145,275 —
22,521 feet pile foundation, at $2 per foot,	45,042 —
10—20 inch stop cocks, at $250, - -	2,500 —
2200 feet of rising main, 20 inch, at $5,	11,000 —
4 air cocks, at $50, - - - -	200 —
	$273,797 —
Reservoir on Barbadoes Neck - -	16,700 —
Crossing the Hackensack, - - -	21,488 —
Reservoir on Bergen hill, - - -	54,037 —
Distribution, - - - - -	227,940 74
Contingencies, including superintendence, 10 per cent. on $593,962.74, - - -	59,396 27
Amounting to	$653,359 01
To compare this with the others, should be added the capital, the interest of which is the cost of running the engines ($8,000) amounting to	133,333 33
	$786,692 34

APPENDIX B.

Analysis of water from the Passaic river, taken at high tide, four miles above Newark, N. J., in October, 1851.

The specific gravity, at a temperature of 60° Fah., 1.00011.

The water is clear and transparent, but appears faintly wine colored, when a few inches in depth are examined from above.

It yielded a sediment of organic flocculi and earthly matter, amounting, in 3,720 cubic centimetres,* to 0.0805 grammes,† which, under the microscope, presented few living forms, and these, such as occur in all open, healthful waters.

The water has perceptible taste, especially when retained a little while upon the tongue. It may be described as being like that of muddy water in a clay soil.

A sensitive solution of litmus added to the water gave no acid reaction.

An alcoholic solution of soda soap gave an immediate white cloud, while distilled water gave none. This cloud proved to be not more dense than that of a well water in constant use for every variety of purpose in the kitchen and laundry. A practical experiment showed, that the Passaic water, for washing purposes, is not inferior to the well water with which it was compared, and which is considered a *soft water*, fit for every kind of family use.

Nitrate of silver gave a ready precipitate in the water, without concentration—indicating the presence of *chlorides*.

In the concentrated solution, chloride of barium gave a precipitate, which did not dissolve in hydrochloric acid—proving the presence of sulphuric acid.

Oxalate of ammonia gave a precipitate soluble in hydro-

---

* 4543 cubic centimetres=1 imperial gallon.

† A gramme=15,444 grains troy.

chloric acid, and insoluble in acetic acid—indicating the presence of *lime.*

The filtrate from the last precipitate, upon the addition of ammonia and phosphate of soda, gave a white precipitate—indicating the presence of *magnesia.*

Upon boiling the water with baryta and removal of the excess of baryta, by carbonate of ammonia, the filtrate gave, upon evaporation to dryness and ignition a residue which readily dissolved in diluted alcohol, and was only partially precipitated by bichloride of platinum—indicating *potassa* and *soda.*

The baryta precipitate dissolved in hydrochloric acid and boiled with ammonia and chloride of ammonium, gave a precipitate of alumina and a trace of iron.

To another portion of the hydrochloric acid solution of the baryta precipitate, acetate of potassa and perchloride of iron, were added, without (after twenty-four hours,) yielding any precipitate, proving the absence of an appreciable quantity of phosphoric acid.

Boiled in a flask, and the escaping vapor conducted into a mixture of chloride of calcium and ammonia, gave evidence of the presence of *free carbonic acid.*

Upon concentrating the water by gentle heat, a precipitate was thrown down, consisting of *carbonate of lime, silica, alumina, sesquioxide* of *iron* and *organic matter.* Upon evaporating to dryness, and ignition, a part, after blackening volatilized. The residue when moistened, gave a strong alkaline reaction and effervesced with acids, proofs of the presence of organic matter, and of alkaline carbonates after the destruction of the organic matter.

Subacetate of copper gave a delicate bluish white precipitate—indicating the presence of organic acids.

Quantitative Analysis.

The quantitative analysis of the several ingredients, except the chlorine and carbonic acid, was conducted with the hydrochloric acid solution of the ignited residue, derived from slow evaporation of the water to dryness.

Determination of the fixed ingredients.

I. 100c.c. evaporated to dryness over a water bath, gave 0.0126 grammes.

II. 100c.c. evaporated to dryness over a water bath, gave 0.0129 grammes.

I. The residue upon ignition, lost 0.0045 gr.
II. " " " " 0.0053 "
Average, ——— 0.0049 gr.
Leaving of fixed residue, - 0.0081 gr.
" " " 0.0076 "
Average, ——— 0.00785 gr.
Equivalent in a gallon to solid matters, 0.5791 "
Of which the organic matter amounts to 0.2226 "
And the inorganic to - - 0.3556 "
III. 4543c.c. evaporated to dryness and ignited, gave 0.6070 "

The solid matter digested in hydrochloric acid, left an insoluble residue of alumina, oxide of iron, and silica, amounting to 0.0610 gr.

This water was slightly turbid, while that employed in the preceding determination was perfectly clear, it having been taken from the top of the vessel without agitation. This will account for the much larger residue in the latter case.

Determination of Sulphuric Acid.

I. 1514.33 c.c. gave of sulphate of baryta, 0.0619 gr.
=to 0.02128 gr. of sulphuric acid,
=in a gallon to - - - 0.0638 gr.
II. 757.16 c.c. gave of sulphate of baryta, 0.03103 "
=to 0.0110 gr. of sulphuric acid,
=in a gallon to - - - 0.06600 gr.
Average= - - - 0.649 "

Determination of Chlorine.

274.5 c.c. gave, of chloride of silver, - - 0.0405 gr.
=0.0100 grains of chlorine
=in a gallon, to - - - 0.16536 gr.

Determination of Carbonic Acid.

(Expelled by boiling.)

500 c.c. boiled, gave, by passing its vapor through a mix-

ture of ammonia and chloride of calcium a precipitate of carbonate of lime=0.0130 gr.=carbonic acid, 0.00519 gr. in a gallon=gaseous carbonic acid, 27.25 c.c.—or 1.66 cubic inches.

Determination of Lime.

1514.33 c.c. gave of carbonate of lime, -	0.05403 gr.
=0.0302 gr. of lime=in a gallon, to	0.09077 gr.

Determination of Magnesia.

1514.33 c.c. gave of pyro phosphate of magnesia,	0.04103 gr.
=magnesia, - -	0.01502 "
=in a gallon, - - -	0.04509 "

Determination of Alkalies.

757.16 c.c. gave, by the method indicated above, chloride of potassium, and chloride of sodium,	0.0613 gr.
Of which bichloride of potassium gave a precipitate of	0.04675 "
Equivalent to chloride of potassium, -	0.0142 "
Leaving chloride of sodium, - -	0.0471 "
Giving in a gallon	
Chloride of potassium, - - -	0.0852 "
Chloride of sodium, - - - -	0.2826 "

Conceiving the organic acids to have been originally combined with the alkalies, after evaporation and ignition, the latter would exist as equivalent carbonates. If not enough of organic acids to combine with the whole of both alkalies, the excess of soda would exist as chloride. The remaining chlorine would be found first with the magnesium, and second with the calcium. The surplus lime would combine with the sulphuric acid, except that portion existing as bicarbonate, of which half the carbonic acid was expelled by boiling, and determined as free carbonic acid.

According to this scheme, the composition of the inorganic residue of the above water, is as fallows:

In 4543 c.c. or one gallon,

Chloride of Sodium, - - -	0.0655
Carbonate of Soda, - - -	0.1875
Carbonate of Potassa, - - -	0.0131

Chloride of Calcium, - - -	0.0795
Carbonate of Lime, - - -	0.0130
Sulphate of Lime, - - -	0.1104
Chloride of Magnesium, - -	0.0728
Alumina, Sesquioxide of Iron, Silica, - -	0.06103
	0.60283
As determined directly, -	0.6070
Loss, - - - - - -	0.00417

A comparison of the relative amounts of solid matters, organic and inorganic, which the above water contains, with those of various other waters in this country, used for the supply of cities, shows the Passaic river water to be inferior to the best, and superior to some in good repute.

	IN ONE HUNDRED THOUSAND PARTS IN						
	Passaic,	Schuylkill,*	Croton,	Cochituate*	Jamaica,	Albany,	Troy,
Solid residue,	12.7500	9.4170	18.7100	5.3400	5.3560	18.4800	11.8600
Inorganic,	7.8500	7.2938	11.3265	2.9000	3.0560	14.5200	8.2400
Organic,	4.9000	2.1232	7.3735	2.4400	2.3000	3.9600	2.6400

On comparing the amounts of lime and magnesia in this water with those of Schuylkill, Croton and Cochituate, as determined by Professor Silliman, Jr., in the report already referred to, it will be seen, that although the Passaic has more of these two ingredients tending to make a hard water, the difference in favor of the Croton is but trifling.

IN ONE GALLON OF THERE ARE GRAMMES	PASSAIC.	SCHUYLKILL	CROTON.	COCHITUATE
Of Lime, - -	0.0907	0.0679	0.0917	0.00934
Of Magnesia, -	0.0451	0.0012	0.0207	0.00063
	0.1358	0.0691	0.1124	0.00997

This comparison is not strictly fair, for the lime and magnesia of the Passaic are taken from an analysis of the water

* Silliman, Jr., Water Commissioner's Report, Boston, 1845.

without filtration or careful drawing off, and while it contained more inorganic matter than is due to the perfectly clear and settled water. We may justly suppose, that much of the sulphate of lime, if not quite all of it, was held in suspension—not in solution—as were the alumina, oxide of iron and silica. Deducting these two quantities, we have, instead of 0.6070 gr. of inorganic matter, but 0.4356 gr. to the gallon. More, even than this, should be deducted for the total inorganic matter, as ascertained by two deteminations of the perfectly clear water, is but 0.3556 gr. to a gallon. If we conceive the lime and magnesia to be diminished proportionably, we shall have, in a gallon, but 0.0795 gr., instead of 0.1358 gr., which would make the relative excellence stand as follows:—

Lime and Magnesia of the			Passaic,	0.0795
"	"	"	Schuylkill,	0.0679
"	"	"	Croton,	0.1124
"	"	"	Cochituate,	0.0099

A series of experiments with lead, conducted in the same manner that the undersigned prosecuted his experiments in the determination of the suitableness of lead pipe for the service of Cochituate water, has shown, that the Passaic water may be served through iron mains and lead distribution pipes without solicitude.

The pipe assumes, after a time, a coat practically impermeable to and insoluble in the water in which it forms. It would be well, for the first fortnight after the pipes are arranged, to permit the water that has been standing in the pipes over night, to waste before saving any for culinary purposes.

All which is respectfully submitted,

E. N. HORSFORD,
Rumford Professor in Harvard University.

Cambridge, November 26th, 1851.

APPENDIX C.

Mew York, 1st December, 1851.

John D. Ward, Esq., Jersey City:

Dear Sir—I have made a qualitative analysis of two samples of water sent to me, at the request of the Water Commissioners of Jersey City, by Mr. Andrew Clerk.

I find the water contained in the large demijohn, marked *Passaic water*, at Beleville, to contain 3.60 grains of saline and other matter to the gallon, consisting of the following:

Carbonate of Lime,
do. Magnesia,
Chloride of Sodium,
do. Calcium,
do. Magnesium,
Sulphate of Lime,
do. Magnesia,
Organic vegetable matter.

The water in the small demijohn, marked "Morris Canal, at inclined plane at Bloomfield," yields only 2.04 grains of saline matter to the gallon. It contains the same ingredients as that from the Passaic.

The salts of lime and magnesia contained in these waters are the same as exist in almost all natural spring and river water.

The proportion to the gallon being so small, renders either of them all that could be desired for drinking and other domestic uses.

Very respectfully, yours,

JAMES R. CHILTON.

APPENDIX D.

Analysis of water from Bergen hill, by Dr. Chilton.

Carbonate of Lime, - - - -	4.86
Carbonate of Magnesia, - - -	2.21
Chloride of Calcium, - - -	2.08
Chloride of Magnesium, - - -	.94
Chloride of Sodium, - - -	4.31
Sulphate of Soda, - - - -	.44
Sulphate of Lime, - - - -	·88
Oxide of Iron, - - - -	.02
Organic matter, - - - -	.32
Total in a gallon, - - -	16.06 grains.

Dr. George Chilton, in 1833, was employed to analyse several specimens of Croton water, and says, in his report—"The average of these three separate results is, for the half gallon, 2.08 grains, or for the gallon 4.16 grains."

The following report by the same chemist, of an analysis of a specimen of the old Manhattan water, may not be uninteresting, as it will enable a comparison to be made between that which was once thought fit for domestic use in New York and the water of the Passaic river:

Manhattan Water.

Muriate of Soda, - - - -	45.20	
Muriate of Magnesia, - - -	40.00	
Sulphate of Magnesia, - - -	6.00	
Carb. of Lime with a little Carb. Magnesia,	12.80	
Sulphate of Lime, - - - -	4.00	
Extractive matter combined with water,	17.80	
In a wine gallon, - - -	125.80	grains.
Croton water contains, per gallon, -	4.16	"
Passaic water, " " " -	3.60	"
Morris Canal water, " " -	2.04	"

APPENDIX E.

JERSEY CITY, 19th SEPTEMBER, 1851.

John D. Ward, Esq., chairman, &c. &c.

Dear Sir—I have your favor of the 18th instant, in reply I hand you herewith the book of standard rates, charged by the insurance offices of New York, from which you will obtain the information you seek.

On page 9 you will find the rates charged on property in New York city, and on page 23 the rates on precisely similar classes in *Brooklyn*, *Williamsburg*, *Hoboken* and *Jersey City*.

You will notice that first class dwellings pay 15 cents per $100, and the seventh class (wooden dwellings,) of which we have a large proportion, pay 50 cents per $100 more in the last named places, than in New York. On "*special hazards*," that is, foundries, machine shops and other manufacturing establishments, there are no fixed rates, and the book of course will not enlighten you as to the difference upon these.

I believe however, it is an invariable rule, with all judicious companies, that a scarcity or abundance of water, shall enter into the computation of the rates of premium upon this description of hazards, and the same difference should be estimated or nearly so.

I have no doubt that the excellence of the New York fire department, and the superior construction of their new engines, have something to do with the low rates charged upon New York risks; yet an abundance of water tending to the improvement of our own department and machines, and enabling us to *make available* the assistance we could always receive from New York, would, in my opinion, soon reduce our rates to their standard, Some of the New York *large* engines are located quite as near to us as to sections of their own city, and points in Hoboken and Jersey City can be reached in much less time, but as they have discarded the suction hose, as useless, their full benefit would be lost to us, though the waters of the Hudson were within reach.

Very respectfully, your obedient servant,

THOMAS A. ALEXANDER.

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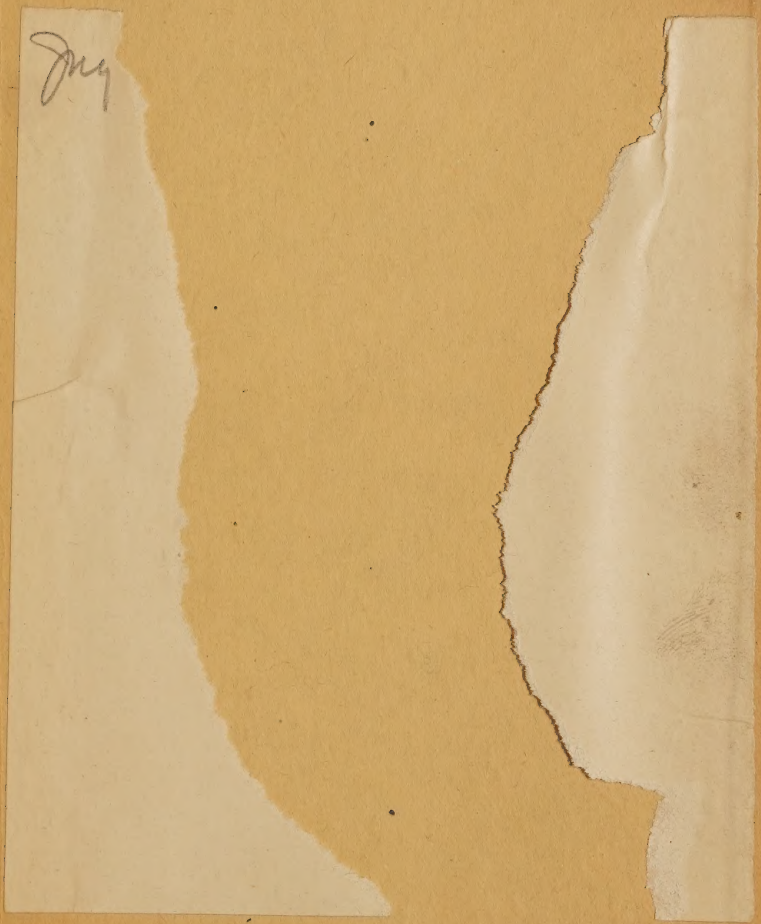
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